Watershed Restoration Program
Adaptive Management Workshop

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Richmond, British Columbia

Workshop Report

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1.0 About the Workshop

1.1 Workshop Goals and Objectives

The Watershed Restoration Program (WRP) has been operating since 1994. The goals of the program are to:

- restore and protect fisheries and aquatic resources in key watersheds throughout the province;
- increase knowledge, information and tools for restoration and management of watersheds; and
- provide opportunities for community-based employment, training and stewardship.

Effectiveness evaluations (EEs) are a crucial element of the WRP, providing a mechanism for assessing whether restoration activities are actually working. However, there are some problems with the way EEs have been undertaken to date:

1. of the hundreds of Ministry of Forests' major works projects completed under the WRP, only 5 or 6 have undergone effectiveness evaluations;
2. of the EEs that have been done, the resulting reports are too large and unwieldy to be of practical use; and
3. EEs are not being done consistently among Regions.

Adaptive management (AM) can provide a framework that provides greater clarity, consistency and direction to WRP plans, prescriptions, works and evaluations. Adaptive management also directly addresses the Program goal of "increasing knowledge, information and tools for restoration and management of watersheds". Watershed Restoration Technical Circular No. 12 introduced the idea of using an AM framework for EEs. However, this will only work if the other elements of watershed restoration (planning, prescriptions, works) are also conducted within such a framework. A workshop was held February 20-21, 2001 to analyse all elements of the WRP from the perspective of adaptive management, and to understand how the four conceptual stages of the WRP fit into the six conceptual steps of AM.

The objective of the workshop was to lay the groundwork for the subsequent development of an Adaptive Management Plan for hillslope, riparian and instream restoration that incorporates Effectiveness Evaluations, feedback to management, and provision for WRP changes when and where necessary. The workshop considered issues of scope in space and time; management actions that could be used, appropriate indicators of effectiveness, key uncertainties, and additional work needed to design detailed monitoring plans.

A selection of people involved in the WRP were invited, including regional and headquarters staff from the Ministry of Forests and the Ministry of Environment, Lands and Parks, and representatives from Forest Renewal BC and industry. The full list of workshop participants is provided in Appendix 1.

1.2 Workshop Process

The workshop combined plenary and subgroup processes to provide for both breadth and depth in the discussions, and to encourage multi-disciplinary cross-fertilisation. The workshop opened with plenary sessions to establish the workshop purpose and set the stage for the discussions, and to reach a common

understanding of a framework for more detailed discussions regarding the application of the adaptive management process to the WRP. This included a brief presentation on adaptive management, and discussion of a conceptual framework illustrating the various pathways by which restoration activities might meet restoration goals.

The participants were then divided into three subgroups: one to discuss sediment management activities and sediment supply/transport; one to discuss hydrology/water management activities and the hydrologic regime; and one to discuss vegetation management activities, and vegetation growth, and large woody debris (LWD) supply and transport. Each subgroup discussed how the adaptive management approach could be used to increase our knowledge regarding the success of these restoration activities in achieving WRP goals.

At the end of the workshop the subgroups returned to plenary for final integration and wrap-up. This included presentations by each subgroup of their findings back to the rest of the workshop participants, questions-and-answers, and a general discussion of "lessons learned" during the workshop.

Appendix 2 contains the agenda as circulated prior to the workshop. While it served as a guideline, minor adjustments were made as necessary to accommodate the dynamic nature of group discussions. The following section describes the results of the workshop.

2.0 Workshop Results

2.1 Initial Plenary Session

The initial plenary session began with introductions, and words of support from John Mallett, Don Gosnell and Brian Nyberg for the Ministry of Forests (MOF) and the Ministry of Environment, Lands and Parks (MELP) to work together to adopt an adaptive management approach to the WRP. This was followed by a brief presentation of the key elements of adaptive management (slides reproduced in Appendix 3), and how the WRP fits into the adaptive management framework (Figure 2-1). For a more detailed description, please refer to the Background Report prepared for the workshop (Murray and Marmorek 2001)[1].

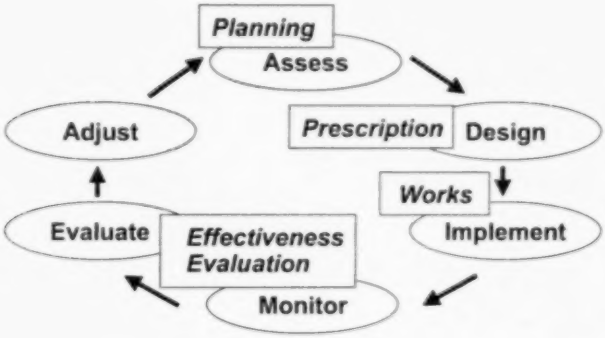


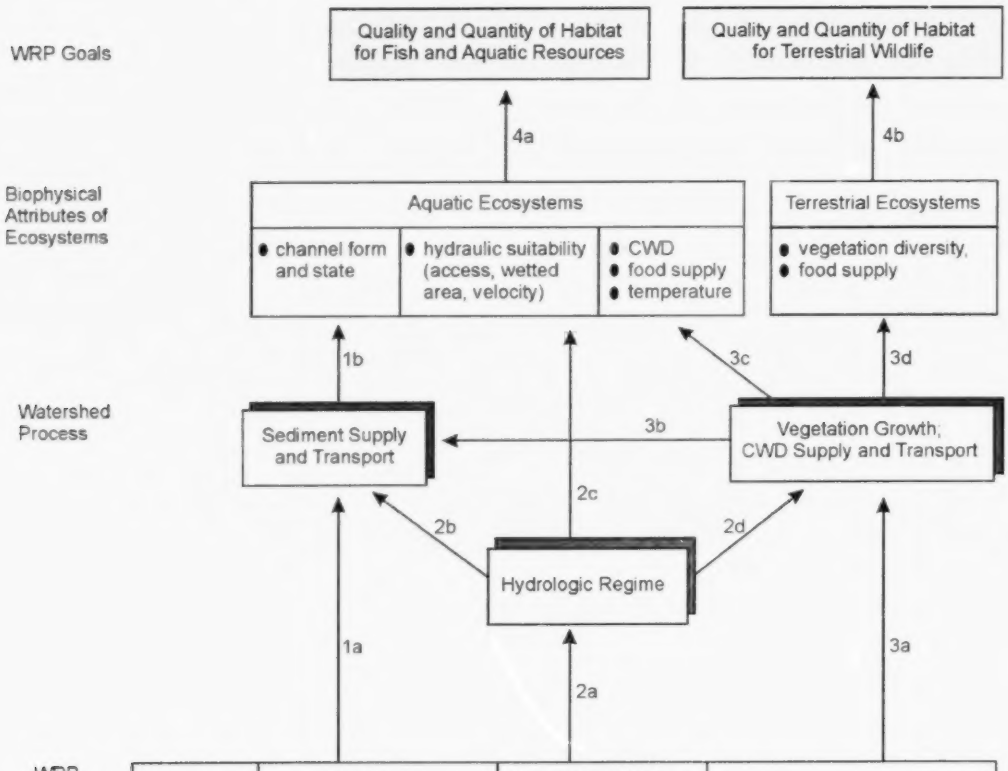
Figure 2-1: How the WRP fits into the adaptive management framework.

A straw conceptual diagram was then presented for examining how WRP activities lead through watershed processes to generate healthy ecosystem attributes (or characteristics) and ultimately achieve WRP goals (Figure 2-2). Activities are at the bottom, and flow up to goals at the top through a series of linkages. The figure is deliberately kept simple – spaghetti diagrams are not helpful for promoting constructive discussions. There are several sub-themes within the diagram:

- individual WRP activities can have multiple benefits (e.g., upslope re-vegetation benefits all three processes shown);
- achievement of WRP goals requires integration of activities in different watershed components (upslope, channel, riparian);
- effectiveness monitoring must occur in multiple components (i.e., monitoring upslope alone is insufficient); and
- each link represents a hypothesis, which may or may not require adaptive management experiments and effectiveness monitoring on some scale to resolve critical uncertainties.

[1] **Murray, C.L. and D.R. Marmorek.** 2001. Watershed Restoration Program Adaptive Management Workshop, February 20-21, 2001. Background Report. Prepared for Ministry of Forests, Resource Tenures and Engineering Branch, by ESSA Technologies Ltd., Victoria, BC. 15 pp.

Process-based Framework for Examining Effectiveness of WRP Actions in Achieving Program Goals



WRP Example Activities

Component	Sediment Management	Hydrology / Water Management	Vegetation Management
Hillslope	• road works, deactivation • slope stabilization • revegetation • gully rehabilitation	• drainage control • soil bioengineering • revegetation	• revegetation
Stream Channel	• sediment addition, removal	• channel reshaping • off-channel habitat • remove barriers • add fishways	• placement of CWD • removal of undesirable debris
Riparian	• bank stabilization	• drainage control	• revegetation; shade control • soil bioengineering • bank stabilization

Figure 2-2: Conceptual diagram: pathways by which restoration actions might affect WRP goals.

To jumpstart subgroup discussions, example text explaining the arrows in the diagram was also presented (Table 2-1). Each of these was phrased as 'positive' impact hypotheses (i.e., as though they were true). The intention was for these linkages to be considered (and the statements revised as necessary) in subgroups.

Table 2-1: Example hypotheses describing the linkages shown in Figure 2-2.

Link #	Link description / hypothesis
1a	WRP sediment management activities restore and maintain natural watershed sediment supply and transport processes.
1b, 4a	The restoration and maintenance of natural processes of sediment supply and transport leads to a channel form / state suitable for fish and other aquatic life.
2a	WRP water management activities restore and maintain a natural hydrologic regime.
2b	The achieved hydrologic regime supports natural processes of sediment supply and transport.
2c, 4a	The achieved hydrologic regime provides hydraulic conditions suitable for fish and other aquatic life.
2d	The achieved hydrologic regime supports natural vegetation processes.
3a	WRP vegetation management activities restore and maintain natural vegetation processes (e.g., growth in the upslope and riparian zone, CWD supply and transport).
3b	The achieved natural vegetation processes support natural sediment supply and transport processes.
3c, 4a	The achieved natural vegetation processes provide CWD, food supply and temperature conditions suitable for fish and other aquatic life.
3d, 4b	The achieved natural vegetation processes provide the diversity of vegetation and food required to support terrestrial/riparian wildlife species.

The participants were divided into three subgroups, each focussing on different subsets of activities and linkages in the diagram:

Subgroup 1: Sediment management activities → sediment supply and transport → habitat (links 1a, 1b, 4a);

Subgroup 2: Water management activities → hydrologic regime → habitat (links 2a, 2b, 2c, 2d, 4a); and

Subgroup 3: Vegetation management activities → vegetation growth, supply and transport → habitat (links 3a, 3b, 3c, 3d, 4a, 4b).

It was suggested that each subgroup undertake the following tasks / questions:

1. Review / revise the set of activities listed for your subgroup (the three columns at bottom of Figure 2-2).

2. What are the critical uncertainties in determining whether or not the complete set of these activities (i.e., across all components) have effectively restored and maintained watershed processes, moved aquatic ecosystems towards healthier attributes, and contributed to WRP goals? Prioritise by region.

   {Example for Subgroup 1: Have all the sediment management actions restored sediment supply and transport processes to a level that maintains the desired channel form and state?}

   {Note: It may be that one of the uncertainties is knowing what natural processes and healthy attributes are desired for a given watershed.}

3. Pick one of these uncertainties for remaining subgroup discussion.

4. Work through Adaptive Management steps 1, 2, 4, 5 and 6, as outlined in agenda.

During this session a number of discussion points and questions were raised. These need to be considered and addressed as the WRP moves towards an adaptive management framework.

- Who are the managers that the AM approach would be helping? Who controls the management actions within the WRP?
- How do we influence FRBC, which is the current source of WRP funding? If AM requires a different approach to planning and allocating funds, this needs to be manifest within the funding agency. It was pointed out, however, that the WRP will persist even if FRBC funding does not, so WRP design and direction should not be hindered by the current FRBC funding model.
- The government tends to focus more on Implementation than the other steps within the AM approach.
- Good experimental design will require looking at spatial replication across logged, unlogged, and restored watersheds.
- What is the difference between AM and research? AM is aimed more at looking for what works, rather than why. From the point of view of achieving restoration goals, we are interested in what works, regardless of how or why. Research is aimed at looking at the reasons for why given restoration activities work, and delves into the detailed level of investigations necessary to discover this. While EE within the WRP should not be undertaken as "research", research can provide very valuable input into the WRP. Routine Evaluations, Intensive Effectiveness Evaluations and Operational Techniques Refinement can provide information useful to deciding upon important research questions to be answered, and research results can in turn be used to modify and improve these types of evaluations within the WRP.
- Of all of the debris structures installed as part of the WRP, how many are still in place? How many are still stable? Are they creating pools? Creating scour? Are they actually improving fish abundance?
- It is unrealistic to expect to get perfect experimental design through the process of Routine Evaluations, particularly because there may be a lot of qualitative information. A decrease in standards may need to be accepted to implement the WRP within the AM framework (particularly when RE are used for Step 4).
- We don't have to do it all from scratch here; we can learn from other locations. But we also need a strategy to ensure that what is learned elsewhere gets passed on to us.
- Licensees must be involved, since they lead the process of preparing restoration plans. The MOF and MELP review the plan, but have no signoff authority. The only authority the Ministries have is to issue permits to do the work, but there have been cases where the work has gone ahead without a permit.
- Barriers to AM include time, funding, expertise, and current legislation.
- The most critical gap right now is the application of AM at the program level.

Participants explored what would be adjusted based on various results from adaptive management and effectiveness evaluation studies. Figure 2-3 shows a hierarchy of spatial levels, together with different

levels of adjustments, from operational techniques at the site level to policy and programs at the watershed and regional level. Data at higher levels are likely to be more qualitative than quantitative, but still of potential value to policy and program decisions.

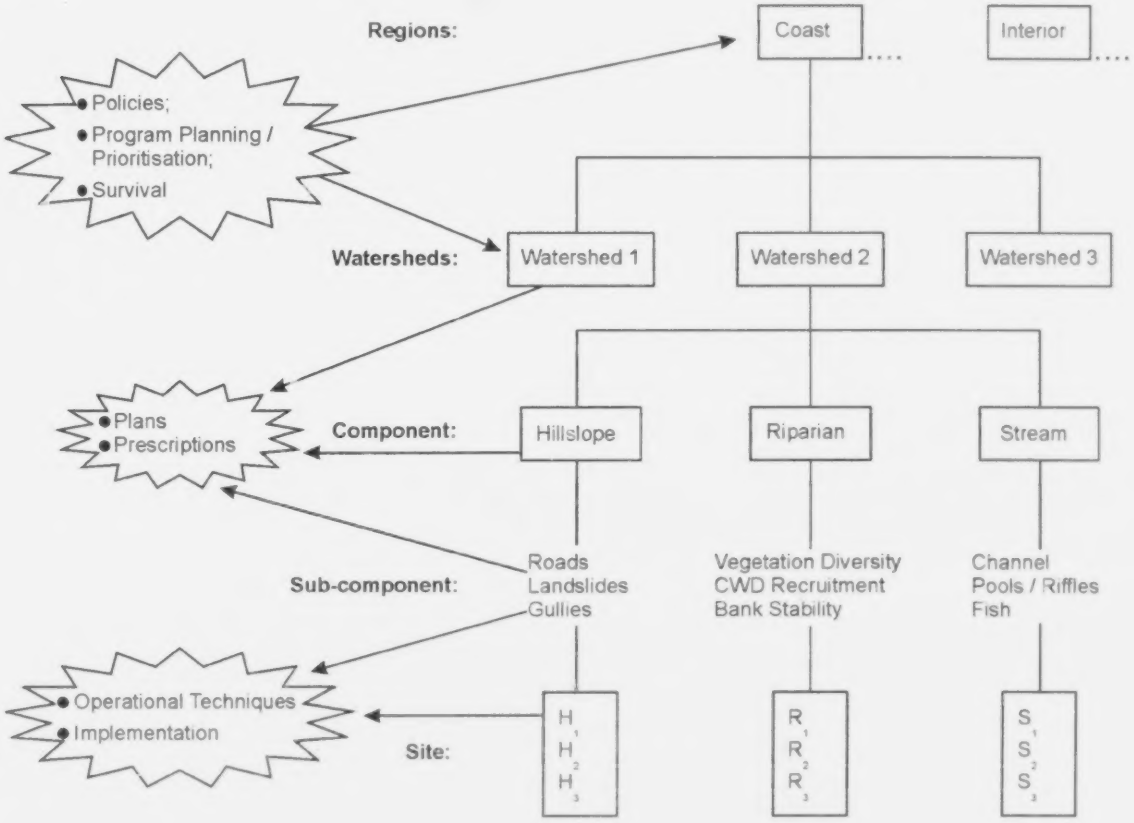


Figure 2-3: Different spatial levels of evaluation of AM designs provide feedback to different components of the WRP.

2.2 Subgroup 1: Sediment Management

The Sediment Management Group followed fairly closely the structure laid out in the agenda, though the topics were not dealt with in a linear sequence. The subgroup began by discussing some of the key uncertainties in how WRP sediment management activities affect fish habitat and aquatic ecosystems (i.e., links 1a, 1b, 4a in Figure 2-2). Having gone through this discussion of uncertainties, the subgroup selected one of them for assessment using the adaptive management approach. The subgroup spent some time on AM steps 2, 4, and 5 (i.e., design, monitoring and evaluation), but the exploration of these steps was limited by the length of time available for subgroup discussions. Barriers to the implementation of any of the steps in the adaptive management process were raised by participants at various times, and noted on a flipchart as the discussion proceeded. These barriers are listed at the end of this section, together with some of the possible bridges around these barriers. However there was insufficient time to creatively explore other bridges, so that the ratio of barriers to bridges is rather high.

2.2.1 Uncertainties

The subgroup used a silent generation exercise, whereby each participant independently wrote down those uncertainties which, in his or her view, most significantly impeded the understanding of how sediment management activities ultimately affect the quality and quantity of fish habitat. Then we went around the table with each participant offering up one uncertainty until all were recorded. They are described below.

Bank Stabilisation

If the riparian zone was logged all the way to stream banks (i.e., prior to the application of the Forest Practices Code) how can you stop sediment from moving off of banks.

What methods are most effective in stabilising banks in such situations?

How much of the overall sediment problem in channels is caused by unstable banks?

Is the fraction of sediment delivered from banks significant relative to the overall sediment budget, particularly when considering the large amount of upslope sediment delivered in the freshette?

Selection of Stabilising Vegetation

Over the long-term, will this method work or fail?

There are considerable employment benefits associated with replanting vegetation, but it is an expensive activity and involves complex bio-engineering, which has an uncertain likelihood of success. Is it better, in some situations, to just let nature take its course?

Percent Disturbance of the Watershed

As the percentage of logging in a watershed increases from 0 % to 100 %, the "naturalness" of sediment processes is likely to decline. However, the shape of that decline is uncertain (Figure 2-4). This raises the question of how much logging implies "non-natural" sediment processes? What is the natural disturbance regime to which WRP sediment management activities are intended to return the system? How far along the declining curves in Figure 2-4 represents a point of no return in turns of restoring natural sediment processes? If we were to look at a set of watersheds spanning a range of percentage logged (Figure 2-4) could we test the watershed assessment process and the assumptions made therein with respect to the probability of success in restoring watersheds?

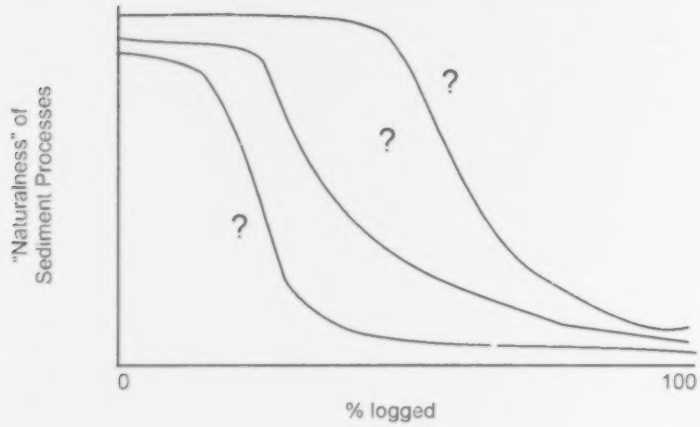


Figure 2-4: Possible changes in sediment processes with percent of watershed logged.

When Should We Control Sediment and When Not?

There are several situations in which there may be good reasons for not doing sediment management activities:

- When the sediment delivery is likely to end up far from the stream and not affect fish habitat. How far away from the stream is far enough?
- When the extent of damage to upslope areas and associated stream channels is too severe to be reversed.
- When it makes more sense to allow the system to recover on its own than to implement sediment management activities.

The third situation listed above raises several questions. At what rate do channels and fish habitat recover through natural sediment movement? Will restoration works (e.g., cross-ditches) cause more damage than natural recovery? Is maintenance sometimes more cost effective than restoration? For roads in the interior, it may be that in some cases it would be more cost effective to put WRP money into the bank and use the interest on that money for road maintenance, rather than spending the capital on very expensive road deactivation works.

Should Standards of Sediment Delivery Vary with Watershed Objectives?

Regional variations in fish species, water quality objectives, topography and climate imply different sensitivities of the aquatic ecosystem to upslope sediment delivery. Logically, this should translate into different standards for how much sediment is delivered.

Fine Sediment from Roads and Other Non-Point Sources

Literature estimates vary on how much fine sediment is delivered to streams from roads and other non-point sources. How does this load vary with the road design, maintenance level, and time (either age since construction or age since deactivation)? What is the ideal level of effort in road deactivation which

generates the greatest benefit (i.e., is there a point beyond which increased effort has diminished effort, as illustrated in Figure 2-5?).

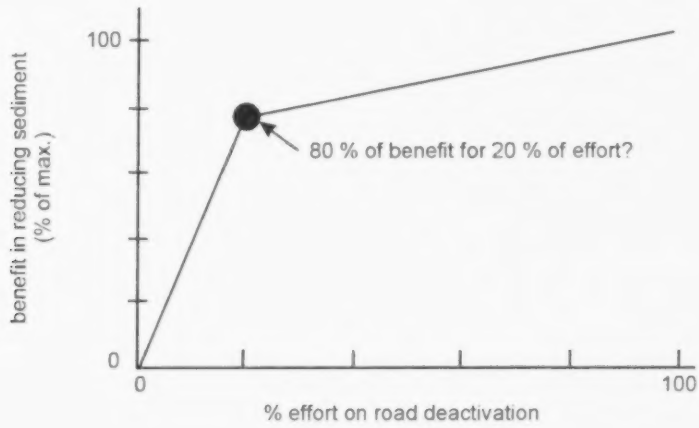


Figure 2-5: Possible point of diminishing returns from efforts to de-activate roads.

What is Best Allocation of Sediment Control Funds Across Different Components (e.g., hillslope, channel, roads, landslides, gullies) within Different Watersheds?

Participants felt that this was too complex a question to address within the limited time of the workshop, but that ultimately this is a key uncertainty meriting further effort within both extensive and intensive effectiveness evaluations.

How Effective *are Professional Judgements, Guidebooks (WRP circulars) and the Whole Set of Consequent Sediment Management Activities?*

This question relates to the whole set of impact linkages in Figure 2-2 between sediment management activities and the quality and quantity of fish habitat and aquatic resources (i.e., links 1a, 1b, and 4a).

This uncertainty was selected by the sediment subgroup as the key one to be pursued further in subsequent discussions. One of the concerns raised is that consultants and licensees don't read much of the material that has been prepared, as they already have too much to read and prefer to do what they think is best anyway. The assessment of risks of sediment landslides is based largely on personal perception and experience. Judgements also vary with whom one is working for, since the liability consequences of a road failure and possible personal injury or death are much more significant for the licensee than for government agencies. Other factors (e.g., community relations) also affect the prescriptions which are made. For example, even though putting up a fence to prevent cattle from reaching a stream may have the greatest value in reducing sediment loads to that stream, this action may be so unpopular with local land users that it is not recommended in the prescriptions.

2.2.2 Assessing the Problem

For the uncertainty indicated above, the subgroup proceeded through the steps of AM Assessment: 1) objectives; 2) alternative hypotheses; 3) activities; 4) indicators; and 5) space and time. Each of these are described below.

Objectives

What is meant by the word "effective" in the question listed above in the shaded box? To be effective, a set of sediment management activities should, over the long-term, meet all of the site, component, and watershed level objectives laid out in the watershed plan. Over the long-term, an effective set of sediment management activities is one which increases the resilience of the watershed to major sediment-delivery storm events, relative to how the watershed would have performed if unrestored. The term "resilience" refers to the level of sensitivity of fish habitat and aquatic ecosystems to such perturbations. Stream channels and fish populations have naturally co-evolved with the climate in each region, and the level of natural disturbances which occur there. The objective, therefore, is to restore sediment supply and transport processes (link 1a in Figure 1-6) back to the regime which would naturally occur, not to prevent all sediment delivery to stream channels, which would degrade the channel.

Alternative Hypotheses

The subgroup developed the following alternative hypotheses. Note that they are not all mutually exclusive. Comments on these hypotheses are included below.

H_0: *There is no change in fish habitat as a result of WRP sediment management activities.*

This is a null hypothesis, whose rejection would either show that WRP has a net benefit or a net detriment to fish habitat (likely the former but just to be complete we should allow for the possibility for the latter in some circumstances).

H_1: *Current methods are effective in managing sediment and restoring habitat.*

Here the term "effective" refers to the meanings outlined above under Objectives.

H_2: *Effectiveness varies with the competency of the professionals who develop plans and prescriptions, and those who implement activities on the ground (e.g., number of years experience, level of specialisation).*

The first part of this hypothesis (developing plans and prescriptions) may be testable in that the individuals responsible are listed on those documents. At present, the second part of this hypothesis is not testable. Fore example, there is currently no record of which backhoe operator was responsible for which sections of a deactivated road, though there is anecdotal evidence that the skill levels of such operators can make a significance difference to the outcomes of activities. Note also the interaction of this hypothesis with H_4 below, since failure of a particular professional's prescription may have been due to the fact that the watershed or sites were very challenging and had a high risk of failure.

H_3: *Training courses and required certification would be more effective than current methods using guidebooks and circulars.*

Though many training courses have been offered, and many people trained, such training is not mandatory. Participants wondered if a certification program should be a prerequisite for undertaking various WRP planning, prescription or implementation activities. A "mentoring program", whereby very

experienced geo-technical and other specialised professionals work with new recruits to the field, might also generate greater knowledge transfer and long-term effectiveness than existing training curricula.

H_4: Effectiveness varies inversely with the risk rating of the site in the original prescription.

Sites are given a low, medium or high risk rating in prescriptions, and one would expect that those sites with high-risk ratings would have a reduced chance of successful, effective sediment management activities.

H_5: Effectiveness varies with the incentive of the licensee to implement activities well.

There appear to be some licensees who are extremely dedicated to doing the very best job in implementing sediment management activities, whereas others are more interested in recovering overhead costs for their equipment and following the stated prescriptions sufficiently to recover costs. This hypothesis should be testable by comparing the effectiveness of sediment management activities undertaken by different licensees under comparable circumstances (i.e., similar risk ratings of sites). This issue of licensee incentive is further discussed under the barriers and bridges section (Section 2.5).

Sediment Management Activities

The subgroup reviewed the set of activities listed in Figure 2-2 and had only a few modifications. The hillslope activities include:

- road works and road deactivation;
- slope stabilisation;
- revegetation; and
- gully rehabilitation in the vicinity of roads.

Channel activities include:

- redistribution of sediment;
- the creation of off-channel refugia;
- adding CWD to create sediment storage in either the channel or floodplain; and
- stabilising banks.

The subgroup felt that activities in the riparian component were more related to revegetation, and that bank stabilisation activities were really part of the channel component.

Indicators

There are several indicators which could be used for both routine and intensive effectiveness evaluations. The difference between the indicators used in these two types of studies is that in the former case they would be largely qualitative whereas in the latter case they would tend to be more quantitative. For the hillslope component, it is generally easier to identify ineffective results than to identify effective results. This is because it is easier to detect when sediment has moved, than to conclude on the basis of no sediment movement that the activity has definitely been effective. Some of the indicators worth considering are:

- Has there been sediment movement (e.g., from a crossditch)?
- Has a slope failed?
- Are sediment control structures still in place?
- Has revegetation been successful?
- Are gullies in the vicinity of roads still hazardous?
- Are roads themselves a landslide hazard?

Some of the indicators recommended for the channel component include:

- Is CWD still in place?
- Is the CWD meeting physical and biological objectives (assessed qualitatively for routine evaluations and more quantitatively for intensive evaluations)?
- Is the state of the channel, as assessed through the CAP (channel assessment procedure) consistent with the component objectives for the channel? The CAP state provides an indication of decadal scale responses. At present it is only measured in a small number of watersheds but should be measured more generally so as to set a baseline for long-term effectiveness evaluation.
- Water turbidity after storms, compared to a control watershed and measurements taken prior to restoration (i.e., a before-after-control-impact design for intensive evaluations).
- Gravel quality.
- Cross-sections of the channel at sites of major works to asses the level of bank erosion.

The subgroup discussed whether or not it was possible to develop an indicator of the cost-effectiveness of sediment management activities. At present this is hard to estimate since biophysical effectiveness is judged by the licensee, MOF, MELP, and the public, but cost information is strictly between the licensee and FRBC. In this context it was mentioned that the FRBC financial audit primarily tracks the paper trail of expenditures and unit costs. Some of the outputs generated through this audit are of questionable relevance. For example, one licensee at the workshop mentioned that the watershed assessment of a 2 km stretch of road had only recommended one crossditch which affected the drainage on only 0.1 km of that road. FRBC recorded this as restoring 2 km of road, while in reality only 0.1 km of road required restoration and only 0.1 km of road was restored.

At a program level, participants felt that organisation of the results of routine effectiveness evaluations into a form like Figure 2-6 might provide useful feedback to FRBC, agencies, and the public on overall program effectiveness. Bar charts like Figure 2-6 could be generated for both the implementation of activities (i.e., in what percentage of cases were activities implemented as prescribed?) and the effectiveness of activities (judged for these extensive studies on a qualitative basis only).

Participants noted that several caveats should be associated with the presentation of such data:

1) there is a risk that these data could be misinterpreted;
2) the data are only qualitative and the results of subjective assessments by different people;
3) the licensee may not in all cases be perfectly neutral in assessing their own work; and
4) some site objectives may be much more important than others.

Regarding caveat #4, a particular watershed may have effectively met site objectives for 12 out of 14 sites but the 2 sites which had ineffective activities caused massive debris torrents with significant impacts on fish habitat. In another case, the two sites with ineffective outcomes may have had no impact on fish. In such a situation, the former watershed would show poorer performance than the latter in meeting the channel site objectives, even though they might show a similar percentage of sites meeting hillslope objectives. Though it might be possible to develop a frequency distribution like Figure 2-6 for some of the sediment management activities separately, often a given activity is meant to benefit not only sediment supply and transport processes, but also the hydrologic regime and vegetation growth. Therefore it may make more sense to simply consider the overall effectiveness for each of the sites within a watershed, rather than attempting to discriminate amongst different watershed processes.

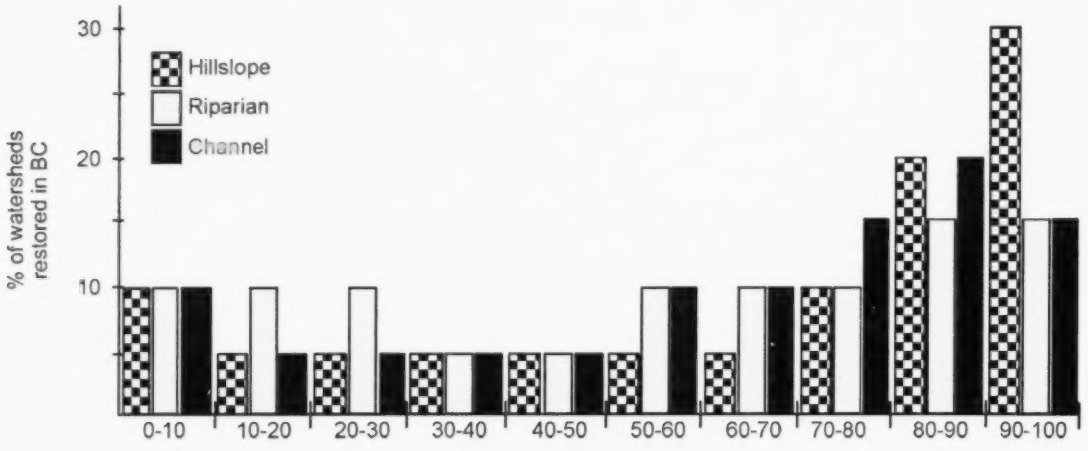


Figure 2-6: Hypothetical frequency distribution of effectiveness ratings for three major WRP components, across all restored watersheds.

When to Measure Effectiveness? (Time)

The subgroup proposed the following sampling frequency for evaluating effectiveness of sediment management activities: routine surveys within one year of installation of works, again four to six years subsequently, and finally after a twenty-year storm has occurred. The timing of the last monitoring is uncertain, and could occur anytime. Although this scheme was specifically intended to evaluate effectiveness of channel component activities, the subgroup proposed extending this to the upslope component as well. At present, upslope sites and works are only re-examined one year following installation. If there are problems detected at that time for some of the works, then those problems are addressed and the sites re-evaluated on future inspections in subsequent years. If there are no problems detected after the first year's evaluation period then those sites are not revisited. This procedure was developed simply because of the very large number of sites that are subject to upslope sediment management control (sometimes hundreds of sites within a watershed) as opposed to the channel component where there are generally only ten to twenty sites requiring evaluation. The subgroup agreed, however, that it would be worth adding a survey following a twenty-year storm of the upslope sites and works. Such a survey would likely need to be opportunistic due to the high costs of helicopter time, but could perhaps be piggy-backed on top of the licensee's survey of the watershed following a major storm.

Semi-quantitative data could be collected at such a time (e.g., the number of stream-impacting slides occurring within different parts of the watershed).

Space

The assessment step in the adaptive management procedure involves defining both the overall spatial horizon (or extent of a problem) as well as the spatial resolution, that is the divisions into which the overall extent is stratified. The subgroup considered all restored watersheds and nearby comparable watersheds as the spatial extent for effectiveness evaluations. The comparable watersheds should ideally include those in three classes: 1) unlogged watersheds; 2) watersheds that have been logged but not restored; and 3) watersheds logged under the Forest Practices Code. The third class is instructive for evaluating the effectiveness of the Forest Practices Code, and could perhaps be funded through some FPC budget rather than necessarily the WRP budget.

Effectiveness evaluations would take place on four levels of spatial resolution: 1) the site; 2) component; 3) watershed; and 4) region. The regional scale would include aggregations or wrap-ups up to the provincial level.

2.2.3 AM Process Steps 2, 4, and 5 (Design, Monitoring, and Evaluation)

The sediment management subgroup dealt with these three steps more-or-less jointly, as we conceived two different levels of evaluation. The first level would be routine, extensive measurements in many watersheds. These largely qualitative measurements would provide a big picture of the program's value to MOF, MELP, FRBC, the public, and government auditors. It would provide general insights on problem areas but would not be of sufficient resolution or accuracy to determine the cause-effects linkages that led to those problems. Given the large spatial scale and sample size, however, these routine measurements could provide evidence of the net benefit of sediment management activities, particularly if these same measurements are made for the comparable watersheds in different classes as indicated above.

The second level design would involve much more intensive measurements in a smaller number of watersheds. This type of evaluation could test alternative operational techniques and get more quantitative data on the effectiveness of sediment management activities on both the upslope and channel components. An example of this level of evaluation would include the Keough watershed and its paired control, the Waukwaas. The Keough River was logged and then restored, whereas the Waukwaas was logged and left unrestored. The subgroup pointed out, however, that the Keough watershed may not be the ideal example for sediment management activities since the upslope conditions were judged to be of fairly low risk to channel habitat conditions. Another example of such an intensive evaluation is the Big Silver watershed in the Harrison drainage which involves before / after evaluations of both upslope and instream restoration activities. However there is no paired control watershed for which comparisons can be made.

In addition to these intensive studies focused mostly on the channel conditions, there are some detailed upslope studies that have been undertaken more recently. For example, Pope and Talbot have been conducting a study in a watershed in the Kootenays to assess sediment movement and scouring at a random sample of 10 % of the upslope sites. This type of study (perhaps labelled routine-intensive) could involve both a fly-over and photo-history collection of data more extensively over the watershed as well as field observations at a randomly selected subset of sites.

Since "control" watersheds are seldom exactly the same as treated watersheds, a study would ideally look at the differences between a logged, unrestored watershed and a restoration watershed both before and

after the restoration activities. The key measurement of effectiveness would be the change in the differences between these paired watersheds for a variety of characteristics (see Figure 21 in the Adaptive Management Presentation included in Appendix 3).

Figure 2-7 illustrates the types of data that would ideally be collected from routine surveys at both the site and watershed level. At the site level, one would assess the percent of sites where works were implemented as prescribed, as well as the percent of sites where works met the site objectives in the prescription. At the watershed level one would assess whether the overview assessment and prescription were adequate. That is, were there some key sites that should have been treated which were missed?

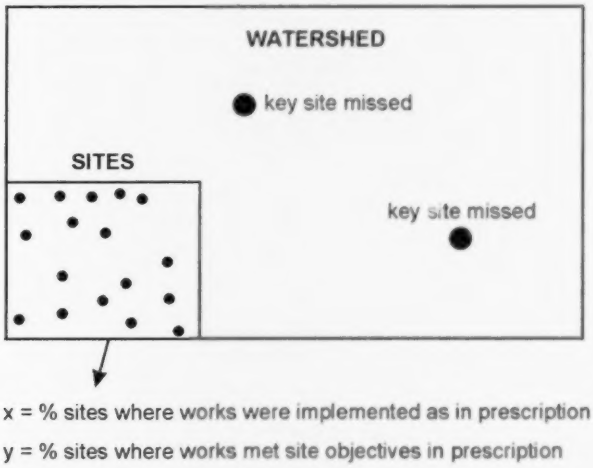

WATERSHED
key site missed
SITES
key site missed
x = % sites where works were implemented as in prescription
y = % sites where works met site objectives in prescription

Figure 2-7: Example of types of data ideally collected from routine surveys at site and watershed level.

Table 2-2 shows an example of how routine data could be analysed at the regional scale. These hypothetical data illustrate how watersheds that were restored after logging showed less of an increase in stream-impacting slides per square kilometre after a twenty-year storm than watersheds which were logged and not restored. These hypothetical data also show that watersheds that were never logged had fewer slides both initially and subsequent to a twenty-year storm, and were comparable to watersheds logged under the Forest Practices Code. Participants noted that it's unlikely the results of regional scale summaries of watershed routine evaluations will come out as neatly as Table 2-2. There are several possible confounding factors:

- The storm track of a twenty-year storm may be quite uneven throughout a region, so that "control watersheds" and treated watersheds do not have the same perturbation.
- Measurement error, particularly for qualitative data, may be significant.
- There is likely to be considerable variation in the time since logging and / or since restoration, which affects the degree to which natural processes have contributed to recovery.
- There may be inherent differences among watersheds, though before / after data would help to control for this.
- The sample size is likely to constrain the significance of observed differences among treatment groups.

Table 2-2: Example of how routine data for watersheds could be analysed at the regional scale. Indicator shown is the average number of stream-impacting slides / km^2 (hypothetical data). Other indicators might include the percent of channel length meeting fish habitat objectives, or the quantity of sediment reaching the streams (rough estimate).

Space (Type of Watershed)	Average # Stream-Impacting Slides / km^2	
	Time	
	Now	After 20-Year Stream
Unlogged	1	3
Logged without restoration	4	10
Restored after logging	4	5
Logged under FPC	1	4

Table 2-3 is an example of how the channel assessment procedure (CAP) and fish habitat evaluations could be used together with effectiveness evaluations of upslope actions to test the hypothesis that upslope sediment management actions are worthwhile. This type of analysis would involve stratifying and organising the upslope and channel site evaluations into groups such that the upslope sites directly above a channel segment were associated with it. One could then assess how closely correlated changes in channel state and fish habitat are with the observed effectiveness of upslope actions. As shown in the table there are three possible outcomes to this analysis: 1) the results are consistent with the hypothesis that upslope sediment management actions are worthwhile and improve fish habitat; 2) the results contract the hypothesis and suggest that sediment management actions in fact may worsen the fish habitat conditions; and 3) upslope sediment management actions appear to have no effect on fish habitat conditions. The design illustrated in Table 2-3 would require two types of control sites – those with no upslope sediment management actions taken, and those with neither upslope nor channel sediment management actions taken. Examining the relative responses of both control and treated watersheds would provide the most information.

Table 2-3: Example of how effectiveness data for upslope and channel sites could be analysed. Effectiveness of upslope actions would ideally be judged relative to two types of controls: Upslope Controls (no upslope actions) and Overall Controls (no upslope or channel actions).

Relative Effectiveness of Upslope Activities	Change in CAP State / Fish Habitat		
	No Change	Worse	Better
Low	no change; upslope activities had no measurable benefit or detriment	low upslope effectiveness may have caused decline in habitat	got lucky or channel activities effective and more important than upslope
Moderate		contradicts hypothesis that upslope sediment management actions are worthwhile	consistent with hypothesis that upslope sediment management actions are worthwhile
High			

2.2.4 Step 6 of the AM Process - Adjust

The extensive level of evaluations would provide potential adjustments at the program level. This would include:

- changes in the prioritisation of watersheds selected for restoration activities;
- changes in the focus and methodology used in watershed plans;
- new and more substantive rationale for continued program funding, including funding for adaptive management designs and effectiveness evaluations.

At the intensive level these evaluations would provide potential adjustments in:

- the details of watershed plans and prescriptions;
- the relative importance given to different sediment management activities (i.e., emphasising those which are most beneficial to fish habitat);
- the methods or operational techniques used;
- watershed assessments (e.g., avoiding prescriptions in situations where restoration adds little to natural recovery processes and therefore is not cost effective).

2.2.5 Barriers and Bridges

Barriers

The following barriers were identified by subgroup participants, and are listed more-or-less in the order they were raised, with some aggregation of points by theme.

- WRP has a cumbersome organisational structure, with multi-agency responsibility for resource management, multiple overlapping regions and inefficient division of responsibilities within a given watershed.
- The WRP objectives keep changing which leads to a lack of program focus.
- There is a lack of support for training within the Ministries and a lack of interest in taking training by consultants. Lack of interest by consultants may reflect absence of a certification program requiring training, or because consultants' perceptions that they cannot afford to give up chargeable work in the short-term, and see a lack of long-term return on such training.
- Regions apply their own twists to FRBC priorities, often avoiding instream work and focussing on upslope work.
- FRBC has a very short-term focus, such that it is hard to fund long-term studies, to obtain equipment for monitoring or to fund storm-dependent effectiveness evaluations as designed in this workshop (one would need a "rainy-day kitty" of funds reserved for such evaluations, almost the way forest fire funding is drawn out of general revenue in a year with serious forest fires).
- FRBC has a much greater focus on employment generation than effectiveness evaluation and learning. Currently FRBC has a high level of control over how money is allocated and a very low level of technical expertise while the agencies have the converse. WRP funds are allocated according to where the cut is presently occurring rather than where watershed damage has occurred. This reflects the recycling of stumpage fees.

- The overall structure of forest management within the province (i.e., a volume rather than area based system of land tenure, and recycling of stumpage fees into restoration activities) does not support the kind of watershed stewardship and long-term effectiveness monitoring which is needed in WRP.
- First Nations' land claims may have a significant effect on how WRP activities are carried out and monitored for effectiveness.
- It has proven difficult to get the Ministries of Forest and Industry to work well together in some of the larger forest regions, though successes have occurred in some of the smaller regions.
- It is very difficult to develop funding for longer than a five-year time horizon outside of the Research Branch – even there it is quite difficult, yet the scale of change in watersheds is decadal.

Bridges

Though the subgroup did not have as much time to reflect on possible bridges around the above barriers, a few ideas were mentioned.

- Use a team approach (i.e., hydrologist, biologist, forester, geomorphologist) from both MELP and MOF working in the same office, taking an integrated watershed approach, ideally with close communications with headquarters staff.
- Rethink the whole allocation of money across ministries, licensees and tasks (i.e., effectiveness monitoring for increasing the amount of learning versus spending money on implementation works).
- Maintain close linkages with other groups doing similar types of work (e.g., the US Forest Service) so that we can learn from each other's successes and failures.

2.3 Subgroup 2: Water Management/Hydrology

Discussions within this subgroup generally fell into five main themes: objectives and uncertainties, evaluating activities and watershed consequences, case example (Rose Creek), logic sequence for blending routine (activity) evaluations with more holistic and intensive watershed investigations, and the role of synthesis and "The Expert Eye".

2.3.1 Objectives and Uncertainties

The subgroup focused mainly on seven key restoration activities related to water management and hydrology: drainage control, soil bioengineering, revegetation, channel reshaping, removing fish barriers, adding fishways, and creating off-channel habitat.

Initial discussions focused on the need to answer strategic questions such as 'how will we know when we are done with the restoration plan' and 'how will we know when we are done with watershed restoration itself?' From this came awareness that, from a water management and hydrology perspective, the main goals are to:

1. "restore" a regionally-appropriate hydrograph to the watershed;
2. "restore" materials transport (e.g., LWD, sediment, bed load) to levels within a natural range;

3. prevent catastrophic hydrologic events; and
4. promote revegetation (by ensuring adequate soil moisture).

It was quickly recognised that most restoration activities employed to achieve these goals (e.g., drainage control, soil bioengineering, revegetation, channel reshaping) have multiple objectives, making it somewhat more challenging to perform assessments. This led to the identification of some obvious uncertainties including:

1. "net" results of all restoration activities in a watershed;
2. are we doing: a) enough, b) too much, and / or c) the wrong things; and
3. what do the fish really 'need'?

2.3.2 Evaluating Activities and Watershed Consequences

Participants ranked the relative ease of performing "routine effectiveness evaluations", as described in Schedule A of the Watershed Restoration Program Standards Agreement. As noted in Table 2-4, determining whether or not an activity has been installed as planned is considered relatively easy. In contrast, it was judged that evaluating whether the activity is working as planned is sometimes more difficult, as in the case of channel reshaping, for instance.

It was suggested that a useful "rule of thumb" is: 'if it takes an expert to write the prescription, then it should be evaluated by an expert." Another suggestion was to generate 'field guides' for soil bioengineering and channel reshaping to provide guidance on what to look for.

Table 2-4: Relative ease of performing effectiveness evaluations for different restoration activities.

Activity	Component	Present?	Working?	Notes
Drainage control	Hillslope	1	1-2	Check after "big" storm
Soil bioengineering	Hillslope	1	2-3	Sediment filtering; long term viability?
Revegetation	Hillslope	1	2	Estimating coverage (%) more challenging
Channel reshaping	Channel	1	3-4	Slow changes – needs professional to evaluate
Remove barriers	Channel	1	1-2	Spawning/rearing use is time sensitive
Add fishways	Channel	1	1	Do fords work for fish?
Off-channel habitat	Channel	1	2-3	

(1=easy, 2=moderate, 3=difficult, 4=questionable)

Some of the key questions that arose during this discussion included:

1. what are the design goals/criteria;
2. what is the appropriate timing, both for evaluations (e.g., 1 yr., 3 yr., 10 yr.?) and for monitoring (e.g., after big storm?);
3. 'evaluating" whether it is 'paying off' over the longer term; and
4. who are the 'users' for the information generated by both the routine evaluations and the intensive monitoring investigations?
5. What about nutrient dynamics?

After some exploration, the distinction between various evaluation efforts became clearer; specifically:

- *Routine evaluations* are to determine if the planned restoration activity was actually implemented as intended, and whether it appears to be working;
- *Intensive evaluations* are an attempt to provide a synthesis perspective on whether the entire suite of restoration activities in the watershed is cumulatively generating the desired results at the watershed level; and
- *Operational techniques refinement* refers to special studies that are designed to help evaluate and 'perfect' specific restoration activities.

As currently designed and implemented, there is not a direct linkage between routine and intensive evaluations; for more discussion on this topic, see Section 2.3.4, below.

2.3.3 Example – Rose Creek

To explore these ideas further, the group chose to focus on a specific case example, Rose Creek, in the Fraser Valley. Some key characteristics of this site include:

- 500 ha site,
- ten years since last forestry activity,
- some land slides have already taken place,
- site is currently greening up,
- system is already instrumented, both at Norrish Creek and Rose Creek (e.g., weather station, flow, turbidity, pH)
- this is a "Cadillac" product, since there will be 90% road deactivation, and two years of hillslope stabilisation, at an estimated cost of ~$500K

The overall goal of the project is to:

- during the summer, have more water in the creek.

There are two competing hypotheses being tested. One is that there will be almost immediate changes in peak flow following road deactivation and initiation of hillslope stabilisation. The other hypothesis is that major changes will occur somewhere in the 5+ year timeframe. The potential interplay between revegetation and drainage control is illustrated in Figure 2-8. The outcome of the adaptive management experiment will be determined by the relative influence of these two types of restoration activity.

Because there is no control system, this AM experiment must rely on a before/after design, as illustrated in Figure 2-9. By comparing precipitation with discharge (Q), both before and after the restoration activities, it will be possible to detect changes in the system's hydrology. It is expected that there will be a more immediate change in the shape of the hydrograph, and a more gradual change in the area under the curve.

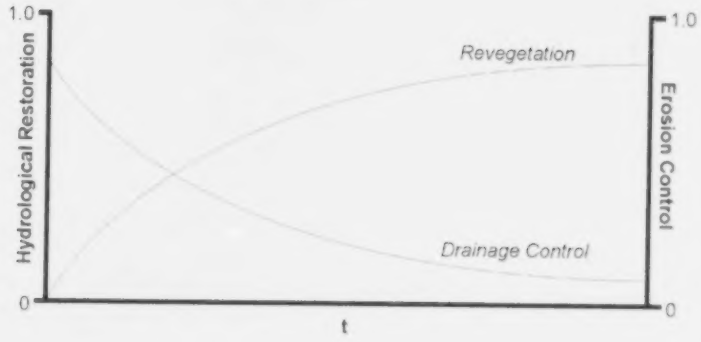


Figure 2-8: Hypothetical relationships indicating relative importance over time of drainage control and revegetation for controlling erosion and restoring 'natural' hydrologic functioning.

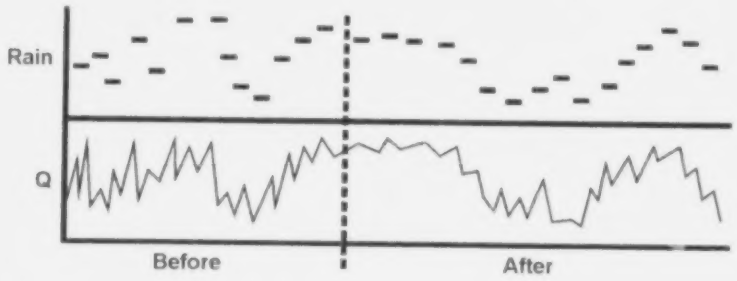


Figure 2-9: Hypothetical illustration showing before-after method used in an intensive evaluation to explore watershed-scale results of restoration activities (Q = discharge).

Field studies at Rose Creek will consist of both routine and intensive evaluations.

Routine evaluation: Intended to generate information confirming:

1. presence of project elements, and
2. their "proper" functioning.

Intensive evaluation: This will consist of generating and evaluating detailed information on precipitation, hydrology, water chemistry, fish, habitat, and other variables.

Much of the work will be done by a graduate student, and preliminary results will be published in *Streamline*. After several years, a more comprehensive effort will be made to judge overall "success", and to draw lessons from the experiment.

2.3.4 Evaluation Logic

Figure 2-10 offers a preliminary example of how the routine and intensive evaluation information could be combined within a learning framework. While the logic tree is not yet complete, it does give readers a glimpse of what such a framework might look like.

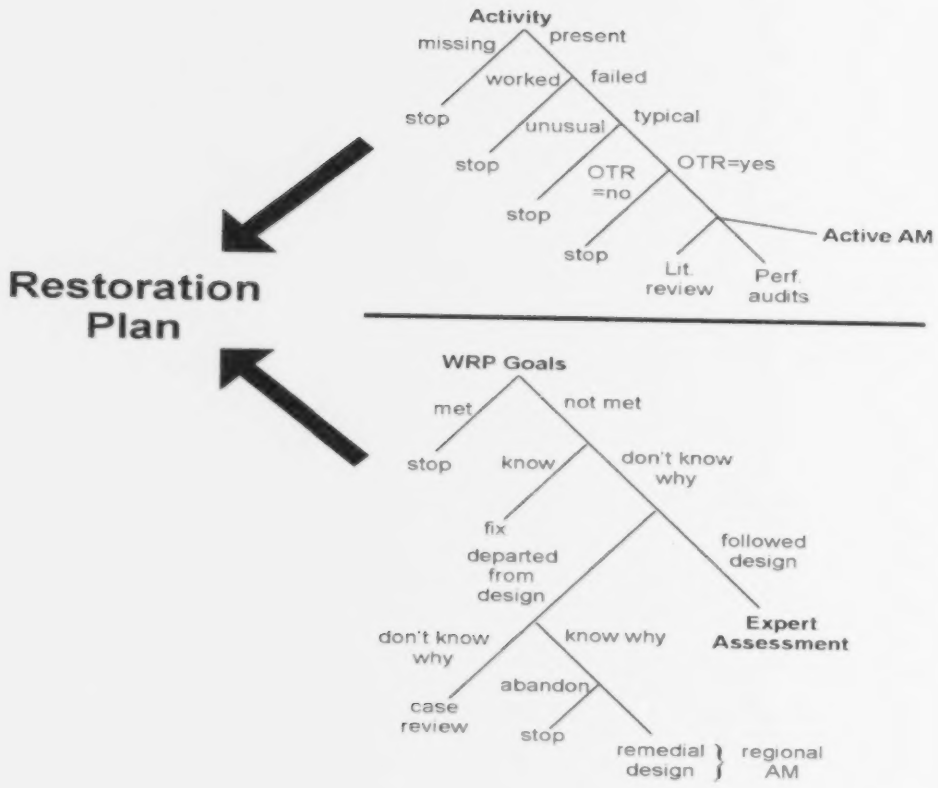


Figure 2-10: Logic sequence for combining routine evaluations (upper half) with intensive evaluations (lower half) to determine whether the restoration plan was successful.

Note that both the upper and lower set of activities compliment one another, and address separate, but vital parts of the system. One without the other is of much reduced value, at least from a learning perspective.

Another way of thinking about this relationship is shown in Figure 2-11. There one finds a hypothetical illustration of how specific restoration activities (A) may affect one or more watershed restoration goals (G). Note that routine evaluations are aimed almost exclusively at providing information concerning the restoration activities themselves, while the intensive evaluations focus on determining if the overall restoration goals have been met. Since there is not a one-to-one correspondence between activities and goals, in cases where the goals are not being met, it may be very difficult to evaluate why. In such instances, it is probably appropriate to allocate that matter to the research community. Finally, when circumstances warrant, it may be useful in some cases to invoke an "operational techniques refinement" process to examine the efficacy and usefulness of particular activities.

After much discussion, subgroup participants came to realise there are essentially four parallel tracks within the WRP (Figure 2-12). Recognition of the oversight track was important, for it led to discussion about the role of the Technical Review and Evaluation Working Group (TREWG). Subgroup participants felt TREWG is well-positioned to take on more of a synthesis role, as discussed in Section 2.3.5.

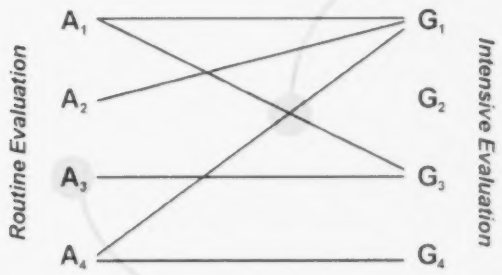


Figure 2-11: Illustration showing how restoration activities (A) may influence watershed restoration goals (G).

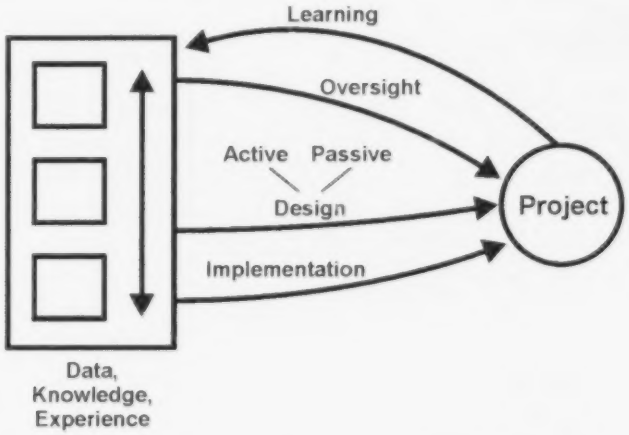


Figure 2-12: Four parallel tracks linking data, knowledge and experience with project implementation.

2.3.5 Synthesis and the "Expert Eye"

Everyone in the subgroup acknowledged that synthesis is difficult. However, there are even large stumbling blocks to undertaking those activities needed to gain the greatest value from the 'experiments' being conducted across BC as part of the WRP. For example, it is unclear who, if anyone, has the mandate to carry out integration and synthesis activities: is it the regions? One suggestion was that the Technical Review and Evaluation Working Group be given responsibility for this area. Some of the questions they could help address include:

1. Are investments moving us toward the WRP goals?
2. If not, why not?
3. Do we have the correct priorities?

As illustrated in Figure 2-13, there are at least five major data streams that are in need of synthesis, if adaptive management is to become an integral part of the WRP. One desirable outcome is, over time, to increase the number of people who can view the landscape, and watershed restoration cases in particular, with an "expert eye". Individual's who have developed the ability to detect the current- or predict the future-state of a system in ways not immediately obvious to a less-practised viewer are said to have an "expert eye". This ability is developed mainly through extensive field experience and a comprehensive familiarity with the area's natural systems and their responses to human activities.

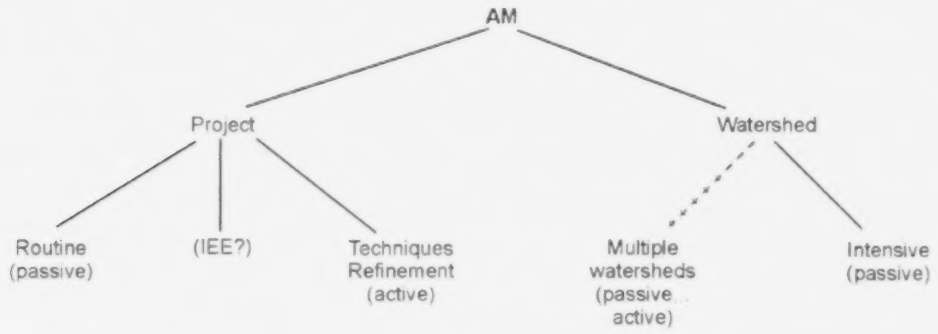


Figure 2-13: Adaptive management at the project and watershed level.

2.4 Subgroup 3: Vegetation Management

2.4.1 Potential Vegetation Management Activities

The subgroup first discussed the suite of vegetation management activities that could (in theory) be undertaken for restoration purposes. These are listed and explained in Table 2-5. The table also identifies in which component the activity could be applied. Note that while herbicide use is listed as a potential activity, it was recognised that it was also currently not allowed under the WRP. It was suggested that this restriction might be investigated using an adaptive management approach. For example, how much can be applied before it becomes dangerous for fish? This may reveal an opportunity to use small amounts of herbicide to control undesirable vegetation along stream banks. Also note that the words "desirable" and "undesirable" are used from a restoration perspective. For example, vegetation that grows quickly and provides an interlocking root mass would be desirable to improve bank stability (e.g., cottonwood), whereas species like alder that do not have interlocking roots and thereby provide opportunities for water infiltration and erosion when they fall are considered undesirable.

Table 2-5: Potential WRP vegetation management activities, by component.

Activity	Component	Notes
Access control	Hillslope, Riparian	- directed at people, and also at ungulates in the interior (e.g., fencing to keep cattle, deer out)
Creating wildlife trees	Hillslope, Riparian	- e.g. carving cavities; topping and facilitating decay
Planting/seeding	Hillslope, Riparian	- to promote vegetation establishment
Girdling	Riparian	- to increase tree mortality (e.g. recruitment of LWD)
Brushing/weeding	Riparian	- to improve growth of desirable species
Pruning	Riparian	- to improve growth of desirable species
Thinning	Riparian	- to improve growth of desirable species
Riprap	Riparian	- bank stabilisation
Fertiliser use	Riparian	- to improve growth of desirable species - not allowed within 100m of streams
Herbicide use	Riparian	- to remove undesirable species - currently not allowed
LWD placement	Riparian, Instream	- for bank protection, fish habitat
Debris removal	Instream	- to modify stream flow/morphology, create fish habitat
Soil bioengineering	Hillslope, Riparian, Instream	- for soil/substrate stability - includes instream re-vegetation for bar stabilisation

2.4.2 Uncertainties

The subgroup then brainstormed a list of uncertainties regarding the effects of vegetation management activities on the watershed processes, biophysical attributes of ecosystems, and WRP goals. Figure 2-2 (Section 2.1) was used as an aid to trigger ideas for this discussion. These uncertainties fall into two conceptual categories: policy questions, and those that could be addressed through an adaptive management approach. There were four policy questions:

1. Which Ministry is responsible for riparian management? It is currently unclear whether it is the responsibility of MELP or MOF to undertake riparian management within the WRP.
2. What objectives should we be managing for within the Riparian Management Zone? Should silviculture, biodiversity or fish resources take precedence? Or are all of these compatible such that we do not need to choose among them?
3. Which program does riparian management fall under? It is unclear whether this falls under the WRP, the Enhancing Environmental Values (EEV) initiative (WRP and the Terrestrial Ecosystem Restoration Program are components of EEV), or the Sustainable Harvest program.
4. What is the timeframe for the WRP goals? This is a common question in restoration programs. The temporal element is important, as when you want to achieve your goals may affect not only the restoration activities you decide to undertake, but also how you measure success.

The remaining questions identified by the subgroup participants are those that could be addressed through adaptive management experiments at various scales. These are listed below, with the larger watershed level questions listed first:

5. What is the optimum timing and conditions for WRP vegetation management activities within a watershed? The subgroup believed that there may be times/conditions within a watershed when/where vegetation management activities may be futile or at least ineffective. For example, is there any point in conducting riparian vegetation management activities if logging is still underway upslope?

6. Do hillslope and riparian vegetation management activities decrease sediment delivery to streams? If so, is this helping fish? These questions strike at the heart of the effectiveness of vegetation management activities for the purposes of sediment management within the hillslope and riparian components.

7. Does bioengineering within any of the components (hillslope, riparian, instream) work in the interior of British Columbia? Subgroup members expressed scepticism, explaining that they have never seen successful bioengineering in the interior.

8. What are the future maintenance demands of vegetation management activities within the WRP? The point was raised that current WRP funding under FRBC does not include a budget for long-term maintenance (i.e., there is no money to go back and fix things), and this might be a problem for vegetation management activities that require future maintenance.

9. Do vegetation management activities speed up link 3c (Figure 2-2) in the interior of British Columbia? Similar to question 7, there was scepticism that any vegetation management activities undertaken within the WRP would speed up, for example, the recruitment of LWD into interior streams (other than actually placing LWD in streams). This question relates to the different vegetation growth rates on the coast versus the interior.

10. What is the optimum timing and conditions to undertake re-vegetation for bank stability? Recognising that streams naturally migrate between degraded, aggraded and stable states, at which state – and moving in which direction – is this activity most likely to be successful? The idea behind this question is again one of potential futility: there is no point in spending time and resources on bank re-vegetation if there is a strong likelihood of a subsequent large water pulse destroying the work.

11. When planting streamside vegetation to create shade to keep water temperatures down, which should be given priority: the main stem or first order streams? Or does it matter? There is uncertainty regarding which is most effective in maintaining a cooler water temperature, and which is best for fish.

12. Under what conditions will the activity of planting vegetation on gravel bars for stability have a net benefit for fish? This question recognises that modifications to one part of the system will affect other parts of the system, and that the larger picture must be considered. For example, gaining the benefit of a stable gravel bar may be at the cost of downstream bank erosion caused by the change in water flow around the bar.

13. What is the life span of instream structures? For example, how long will LWD stay in place, serving its intended purpose (e.g., protection from bank erosion, creation of fish habitat)? This relates back to the maintenance funding issue raised in question #8.

14. Is shoot growth a good indicator of root growth? Root growth (and whether the growth in deep and/or lateral) is a good indicator of the site-level success of re-vegetation activities. Pulling up the vegetation will tell you this, but is rather destructive. It would be useful to be able to use a less destructive means of assessing root growth from shoot characteristics.

2.4.3 Applying the AM Approach for Reducing Uncertainty

Because there was not time to consider them all, the subgroup selected question # 10 above as the example to use in discussing how to apply the adaptive management approach to resolving these uncertainties:

> What is the optimum timing and conditions to undertake re-vegetation for bank stability? Recognising that streams naturally migrate between degraded, aggraded and stable states, at which state – and moving in which direction – is this activity most likely to be successful?

AM Step 1

In discussing AM step 1 (Assess), the group first articulated the management objectives underlying question # 10. The participants then discussed the restoration activities (relating to vegetation management) that might meet these objectives. This was followed by a discussion of the indicators that could be used to measure whether the objectives were being met. The subgroup recognised the need for two types of indicators: indicators of stream state, and indicators of restoration success. Both are necessary to resolve the uncertainty, since the question focuses on what stream state is optimal for success. A hypothesis was offered, but at a general level due to time constraints. The subgroup also briefly discussed the spatial and temporal horizons necessary to resolve the uncertainty.

Uncertainty: What is the optimum timing and conditions (with respect to state and direction, according to Hogan et al, in press)[2] to undertake re-vegetation for bank stability?

Objectives: To improve bank stability and thereby reduce sediment delivery to streams.

Activities: Planting (conifers, cottonwood, and Douglas-fir in the interior), for quick growth and interlocking roots;

Girdling, to improve growth rate of desired species;

Thinning/brushing, to improve growth rate of desired species;

Bioengineering (e.g., coconut mat with willow, cottonwood, red osier dogwood);

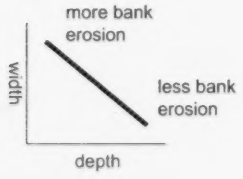
Fertilisation; and

Fencing (to keep out deer, and in the interior, cattle), to allow growth.

E.g., simply fencing a riparian area along the Salmon River for a year and allowing natural regeneration was very successful in establishing riparian growth.

Indicators: Of channel type, state:

- Bankfull width, depth (generally, bank erosion increases as width increases and depth decreases, as illustrated below)



[2] **Hogan, D.L., S.A. Bird, and S. Rice.** In press. Channel morphology and recovery processes. In: S. Chatwin, D.L. Hogan and P. Tschaplinski (eds.). Proceedings of the Carnation Creek and Queen Charlotte Islands Fish/Forestry Interaction Program: Applying 20 years of coastal research to management solutions. BC Ministry of Forests, Victoria, BC. As excerpted from: BC Ministry of Forests and BC Ministry of Environment. 1996. Forest Practices Code of British Columbia: Channel Assessment Procedure Field Guidebook. BC Ministry of Forests and BC Ministry of Environment, Victoria, BC. December 1996. 95 pp.

- Substrate amount, by size distribution
- LWD by bankfull width
- Sinuosity
- Thalwag location

Of success:

- Tree growth (of desired species, but also alder, which is undesirable because of it's non-interlocking roots and is therefore a sign of future erosion problems)
- Bank presence, location
- Natural re-vegetation of sediment bars
- Bankfull width, depth (this is an indicator of both channel type/state and success)

Hypothesis: The best time to re-vegetate for bank stability is when the channel state is trending towards stability from either a degraded or aggraded state.

The subgroup discussed how ideally in Step 1 one would also identify hypotheses (predictions) for how individual indicators would respond to various activities, but acknowledged that there was insufficient time available during the workshop to do this.

Space: These indicators can be measured within a given stream reach. (While replicates along multiple reaches and multiple streams might be needed for optimum experimental design, a stream reach represents the necessary size for each experimental unit.)

Time: 5 – 10 years, to determine channel type and state
3 – 4 years, to see indications of successful growth (note: it would take 15 – 20 years to actually manifest this growth)

AM Steps 2-6

The subgroup ran out of time to discuss these steps in depth. With respect to Step 2 (design), two suggestions were offered. The first was to use models to help identify channel type and state. The second was to use existing information to try to determine the current type and state of any given channel. This is very important, given that it may take 5 – 10 years of observation to determine channel type and state. Rather than starting now and having to wait a decade for answers (a strategy unlikely to receive significant funding) one could use past data and air photos to compile "retrospective" monitoring data.

The participants were asked what they would do in Step 6 (adjust) if they learned that their hypothesis was indeed true. They agreed that the various assessment procedures (CAP, FHAP, RAP, CCPA) should be adjusted to ensure that the assessments included the indicators necessary to identify channel type and state. If this occurred, the assessment results could be used to identify streams that should receive priority for restoration of bankside vegetation.

Lastly, the subgroup briefly discussed the barriers to adopting an adaptive management approach to reducing the uncertainties listed above. The most important issue was the shortage of staff. Current staff is already overworked, and the concern was expressed that they cannot take on extra duties associated with AM. If AM is to be undertaken, staff need direction on what other activities they are currently doing can be dropped. Otherwise there will be little enthusiasm for this approach.

2.5 Final Plenary Session

At the plenary session on the final day of the workshop, the participants had a short brain-storming session on major issues and directions for implementing adaptive management in the WRP program. Figure 2-14 summarises the feelings of many of the participants. Until now, the WRP has had a very high focus on implementation, and very little focus on testing hypotheses regarding the effectiveness of activities (lower right of Figure 2-14). It is in direct contrast to academic scientific research (shown in the upper left part of Figure 2-14) which has a high focus on testing hypotheses and a very low focus on implementation. An intermediate example would be the Fish / Forestry Interaction Program (FFIP) which has done applied research on both testing hypotheses and methods of implementing restoration activities. Participants felt that in the future it would make sense for WRP to move in a trajectory which involves less focus on simply implementation and a greater focus on implementation together with testing hypotheses. As shown in the diagram, however, WRP would still have a much stronger implementation focus than applied research programs.

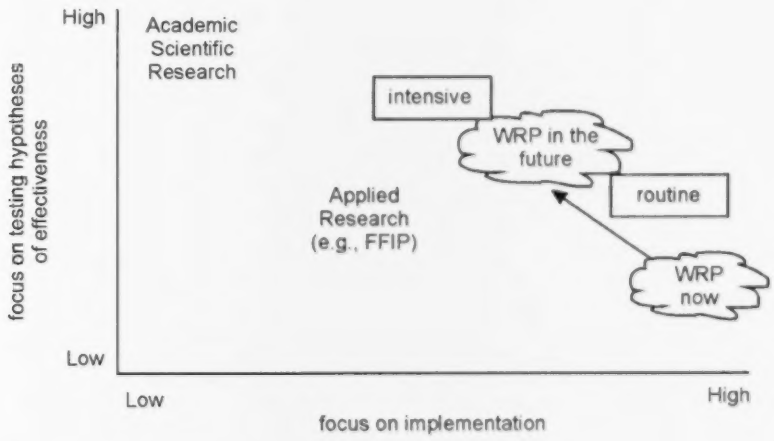


Figure 2-14: Recommended trajectory for WRP.

The participants discussed the difference between testing hypotheses and informal learning. Informal learning is being done by the technical experts who make watershed prescriptions and then revisit their sites. However this learning is not being formalised or necessarily circulated. In addition, 2800 people have been trained in various courses, and a publication (Streamline) distributes information and knowledge gleaned from various restoration projects for the benefit of other people. These kinds of learning are not, however, the same as formal testing of hypotheses of effectiveness and the generation of data over sites, components and watersheds that provide hard evidence for or against different hypotheses.

A related issue is illustrated in Table 2-6, namely the distribution of information to different audiences. Adaptive management designs, the results of routine evaluations, and the results of intensive evaluations have at least five different audiences: MELP, MOF, Licensees, FRBC, and consultants. This information must be organised and presented in different forms for these different audiences. MELP, MOF and licensee practitioners will be most interested in the technical aspects of such information, whereas FRBC and the public will be interested in more general syntheses of the collected data across broad regions.

Table 2-6: Recognising the different information needs of different groups. T = technical information, S = syntheses at broad scale.

	Distribution to Audiences				
	MELP	**MOF**	**Licensees**	**FRBC**	**Public**
AM Designs	T,S	T,S	T,S	S	S
Routine Evaluations	T,S	T,S	T,S	S	S
Intensive Evaluations	T,S	T,S	T,S	S	S

Participants expressed some concern over data management. In particular it isn't yet clear where the routine evaluation data are going to go, and how such information will be synthesised and disseminated. At present, Andrew Wilson of MELP and Glen Moore of MOF are the ones responsible for designing the effectiveness evaluation data forms, and therefore are the focus for suggestions on data management, synthesis and dissemination.

Some participants felt that though this workshop focussed on uncertainties, we should also note what certainties have become evident through the WRP. In general the level of certainty was felt to be highest at the site level, moderate at the component level and lower for the watershed and regional scales where it is difficult to quantify results. In light of this however, there was a stress laid on documenting successes and failures at all four spatial scales. In addition, it was pointed out that it is necessary to take risks in order to learn, that repeating existing methods will not necessarily lead to a progression of knowledge. As an example, it was pointed out that the performance audit for instream works (which involved a routine-intensive examination of 100 – 200 projects) provided valuable insights to MELP personnel, and should be distributed to increase learning for those engaged in both channel and upslope restoration activities.

Participants raised a concern about data quality. In particular routine evaluations involve a lot of subjective evaluations and it is necessary to assess how much variation occurs among independent observers. Such tests would involve independent teams going into the same watersheds and sites and making independent evaluations. Under current practices one team of people travels through a watershed and comes to a consensus on its assessments. This is not the same as having independent teams visit the same watershed on different occasions. Nevertheless, people felt than any information gathered is valuable and that the move towards more formal, quantitative and standardised data should occur gradually, through use of checklists and other forms of procedures. Participants were eager to see effectiveness evaluations get underway as there have been several delays in the development of the data forms. Such evaluations should be starting this spring with a simple two-page form that covers both upslope and channel components, providing feedback to both MOF and MELP personnel. Licensees are to include in such routine data photographs of sites which offer particular learning opportunities, either because of unexpected failures or innovative successes. The intention is to have such forms analysed and synthesised by a consultant, recognising the varying information needs of different groups (Table 2-6).

2.6 Conclusions and Recommendations

This section synthesises the major conclusions and recommendations that emerged from both the plenary and subgroup sessions. Note, however, that this is not intended to represent a comprehensive listing, since each subgroup approached their discussions in a somewhat different manner. Note also that Section 3.0 provides some suggested 'next steps', a listing developed by the facilitators subsequent to the workshop at the request of the client.

In no particular order:

- It is important to identify who are the managers that would make use of the information generated through application of an AM?
- To stimulate learning via AM, FRBC needs to readjust it's approach to planning and allocating funds.
- Likewise, government needs to focus not just on Implementation, but also the other steps of the AM approach.
- Good experimental design requires looking at spatial replication not only in restored watersheds, but also those that have been logged and not restored, as well as those that remain unlogged.
- Information from Routine Evaluations, Intensive Effectiveness Evaluations and Operational Techniques Refinement can all yield useful insights needed to help select important research questions.
- To maximise learning, mechanisms need to be in place to allow a decrease in standards in selected cases (particularly when RE are used for Step 4).
- Wherever possible, personnel should take full advantage of lessons learned elsewhere (e.g., Washington state). This requires that there be a strategy to ensure that lessons gets passed along efficiently.
- Implementing AM requires budgeting adequate time, funding, and expertise.
- WRP needs to streamline its organisational structure to overlapping jurisdictions and inefficient division of responsibilities within a watershed.
- The WRP needs a stable set of objectives.
- There should be more support for training within the Ministries, and a requirement for consultants to take part in these courses. A certification program, requiring training, might be helpful.
- Regions should be discouraged from avoiding instream work in favour of upslope projects.
- FRBC needs to shift focus to support long-term studies, equipment for monitoring, and a means to fund storm-dependent effectiveness evaluations.
- FRBC should reconsider the practice of allocating funds according to where the cut is presently occurring. Instead, funding should be directed to where the watershed damage is greatest. In fact, workshop participants suggested rethinking the whole system for allocating money across ministries, licensees and tasks (i.e., effectiveness monitoring for increasing the amount of learning versus spending money on implementation works).
- The overall structure of forest management within the province (i.e., a volume rather than area based system of land tenure, and recycling of stumpage fees into restoration activities) does not support the kind of watershed stewardship and long-term effectiveness monitoring which is needed in WRP.
- Where appropriate, multi-disciplinary (e.g., hydrologist, biologist, forester, geomorphologist) and multi-agency (e.g., MELP, MOF) teams should be formed to work out of the same office and to adopt an integrated watershed approach, ideally with close communications with headquarters staff.
- There is value in maintaining close linkages with other groups doing similar types of work (e.g., US Forest Service) so we can learn from each other's successes and failures.

3.0 Next Steps

Based upon the workshop objectives and results, the facilitators offer the following suggested "next steps":

1. Discuss with FRBC and senior managers of the Watershed Restoration Program the outcomes summarised in this report along with the identified barriers to adaptive management.

2. Based on results of the discussions recommended above (i.e. if there is support from FRBC and senior WRP managers), develop an Action Plan for helping move the WRP towards the framework shown in Figure 2-1. This would require shifting the focus of WRP from primarily one of implementation to that of broader learning.

3. As part of this Action Plan, hold a Design Workshop to focus on developing and implementing detailed adaptive management plans for both routine and intensive monitoring in at least one *specific region* of the province.

4. Based on this Design Workshop, determine the budget necessary for this regional application of adaptive management to WRP and then submit a funding proposal to FRBC. This would include an allocation of funding for long-term monitoring. As part of this proposal, develop a decision analysis that evaluates benefits and costs of different allocations of funding toward adaptive management.

5. Implement the effectiveness evaluation method worked out by Andrew and Glen for routine monitoring.

6. Develop a data management plan to accompany the evaluation method.

4.0 Definition of Key Terms

The following terms were presented in the background document to ensure participants used the same terms in the same way at the workshop, and avoid confusion and misunderstandings.

Activities versus Objectives

Objectives	The desired outcome (i.e., what you want). I.e. reduced erosion on cut slopes.
Activities	Actions required to achieve an objective (i.e., what you need to do to get what you want). I.e. re-vegetate cut slopes through hydroseeding, or re-vegetate through planting trees.

Different Types of Monitoring

Implementation monitoring	Observation and measurement of activities for the purpose of determining whether the implementation was undertaken as planned. It is a similar concept to "Inspection" (see Table 1), (e.g., if the Implementation Plan specifies hydroseeding only, observing the re-vegetation operation to ensure that only hydroseeding is undertaken, and that the appropriate volume of seed is applied).
Effects monitoring	Measurement of 'response' and 'condition' indicators (see below) for the purpose of determining whether the activities had the desired effects. While the monitoring results will be used to evaluate the success of the activity (a partly subjective process), the collection of the indicator measurements is an objective process (e.g., measure the establishment of vegetation cover and the amount of visible erosion on the cut slope).

Different Types of Indicators

Indicator	A variable measured to provide information about the environment (including the social and economic environment).
Condition Indicator	A variable measured to provide information about the health of the environment. These are indicators that would tell you whether you are meeting your higher-level (e.g., watershed) objectives (e.g., fish abundance).
Treatment Response Indicator	A variable measured to assess the outcome of specific prescriptions and works. These are indicators that would tell you whether you are meeting your lower-level (e.g., site) objectives (e.g., % vegetation cover established).

Appendix 1 – List of Workshop Participants

Name	Affiliation/Address	Phone/Fax
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Stan Gripich	FRBC, Williams Lake	P: 250 398-4899 F: 250 398-4898
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Appendix 2 – Workshop Agenda

Tuesday February 20

8:30am	Welcome Introductions Review of workshop objectives, agenda, process
8:45 am	Brief introduction to adaptive management, with examples
10:00 am	How the WRP fits into the adaptive management approach
10:15 am	**BREAK**
10:30am	Presentation/refinement of a simple conceptual model illustrating links between WRP activities and desired characteristics of aquatic and terrestrial ecosystems
NOON	**LUNCH**
1:00 pm	Break into 3 subgroups; discussion of charge to each group
1:10 pm	*Subgroup discussions* Discussion of key uncertainties regarding how WRP activities affect indicators Prioritisation of uncertainties, by region Pick one of these uncertainties for the remaining subgroup discussion
2:45 pm	**BREAK**
3:00 pm	Identify alternative hypotheses for the selected uncertainty Walk through an adaptive management experiment to test these hypotheses: Step 1 – Assess (objectives, activities, indicators, space, time)
5:00 pm	**ADJOURN**

Wednesday February 21

8:30am	*Continue with subgroup discussions* Step 2 – Design (spatial/temporal contrasts) Step 4 – Monitor (what indicators to measure, where, when)
10:00 am	**BREAK**
10:15am	Step 5 – Evaluate (how would you analyse the monitoring results) Step 6 – Adjust (what would you change, based on the possible outcomes?) Discussion of barriers and bridges for the outlined experiment
11:30 am	**LUNCH** *Facilitators prepare subgroup presentations*
1:00 pm	*Return to plenary* Group 1 presentation (25 minutes) and questions (15 minutes) Group 2 presentation (25 minutes) and questions (15 minutes) Group 3 presentation (25 minutes) and questions (15 minutes)
3:00 pm	**BREAK**
3:15 pm	Insights gained during the workshop Barriers and bridges Next steps: towards an Adaptive Management Plan for the WRP
4:30 pm	**ADJOURN**

Appendix 3 – Slides from Plenary Presentation on AM

The following slides have been excerpted from an MOF/FRBC training workshop:

De-mystifying Adaptive Management

Adaptive Management

AM Logo designed by Gottex Consultants Inc.

Developed for the B.C. Forest Service

Funded by Forest Renewal BC

Developed by ESSA Technologies Ltd.

Definition of AM

AM is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs.

De-mystifying Adaptive Management

Key Characteristics of AM

Management as an 'experiment'
- seeks to learn from management actions
- takes a 'systems approach'

Addresses key uncertainty
- explicitly recognizes uncertainties
- goal is to increase management certainty

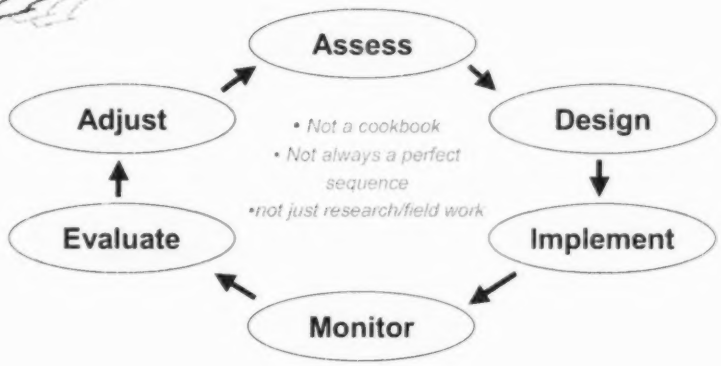
'Closes the loop'
- requires predictions of outcomes
- makes adjustments based on outcomes

AM embodies a simple imperative: policies are experiments - learn from them!

Lee, K.N. 1993. Compass and Gyroscope. Island Press.

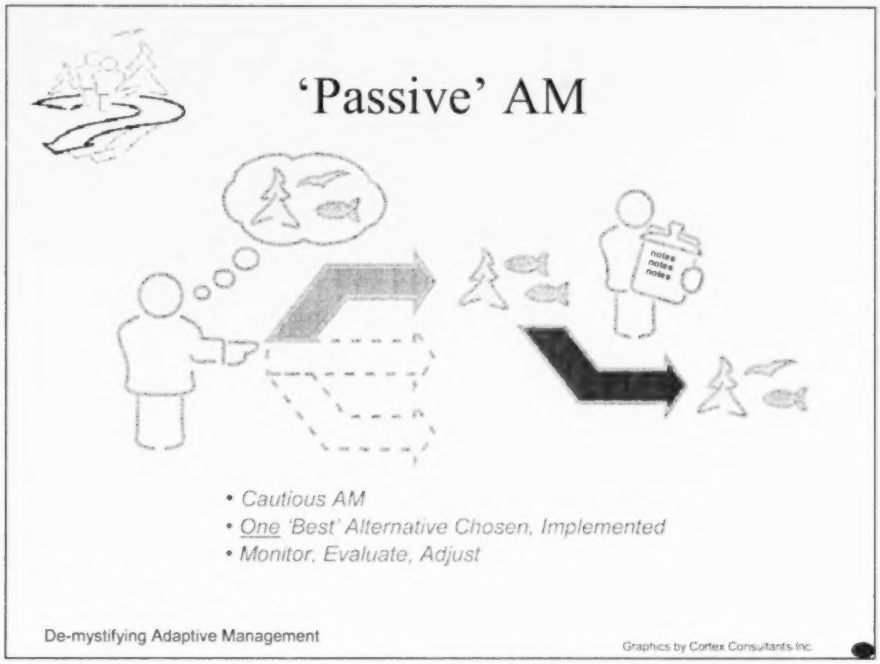
De-mystifying Adaptive Management

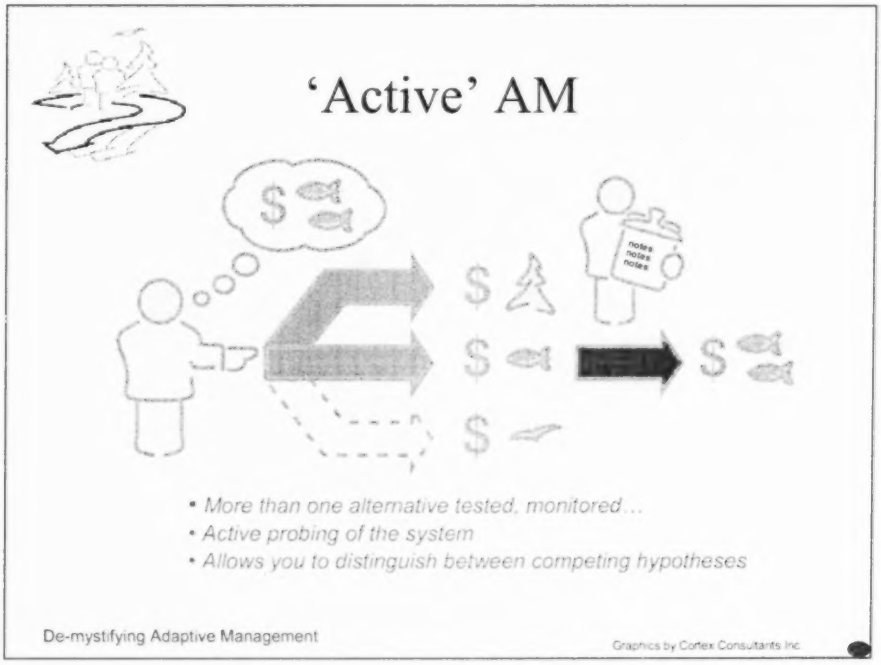
The Six Steps of AM



- *AM is a problem-solving approach to resolve uncertainty.*
- *Uncertainty in management is an AM learning opportunity!*

De-mystifying Adaptive Management


'Passive' AM
notes
notes
notes
• Cautious AM
• One 'Best' Alternative Chosen, Implemented
• Monitor, Evaluate, Adjust
De-mystifying Adaptive Management
Graphics by Cortex Consultants Inc.


'Active' AM
$
notes
notes
notes
$
$
$
$
• More than one alternative tested, monitored…
• Active probing of the system
• Allows you to distinguish between competing hypotheses
De-mystifying Adaptive Management
Graphics by Cortex Consultants Inc.

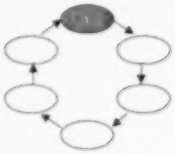
Benefits of AM

AM leads to better, more informed decisions by allowing managers to:

- adjust programs in response to change
- detect effects of management actions
- learn which practices best meet objectives
- improve understanding of system function
- share information/experiences

De-mystifying Adaptive Management

Step 1: Assess



define and bound the problem

↙

define management objectives

↘

identify key indicators

↙

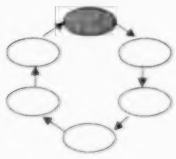
explore effects of alternative actions

↘

identify key uncertainties

De-mystifying Adaptive Management

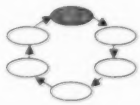
Assessment Tools



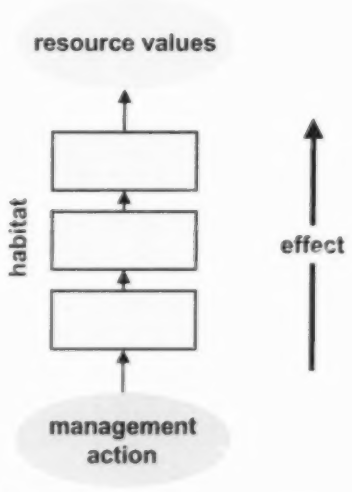
- meetings
- workshops
- conceptual models
- computer models
- hypotheses of effect
- decision analysis

De-mystifying Adaptive Management

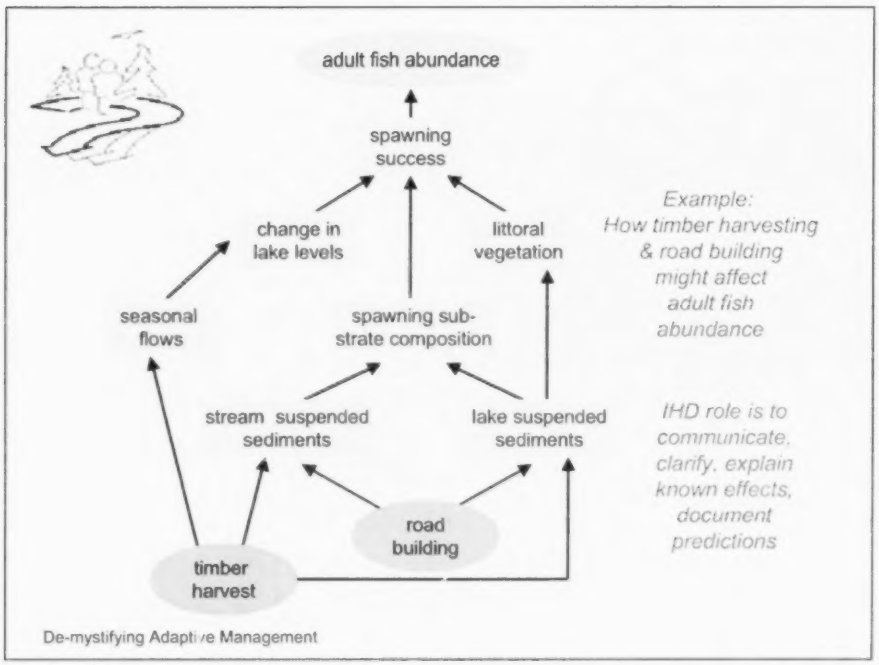
Conceptual Model



impact hypothesis diagram

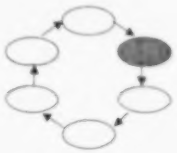


De-mystifying Adaptive Management


adult fish abundance
spawning success
change in lake levels
littoral vegetation
seasonal flows
spawning sub-strate composition
stream suspended sediments
lake suspended sediments
road building
timber harvest
Example: How timber harvesting & road building might affect adult fish abundance
IHD role is to communicate, clarify, explain known effects, document predictions
De-mystifying Adaptive Management

Step 2: Design
design a management plan
design a monitoring plan
plan data management and analysis
predict/document outcomes
state how management actions will be adjusted
De-mystifying Adaptive Management

Design Tools



- experimental design
- literature
- biometricians, scientists
- computer models
- decision analysis

De-mystifying Adaptive Management

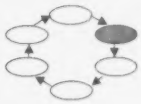
Design Features

Active AM

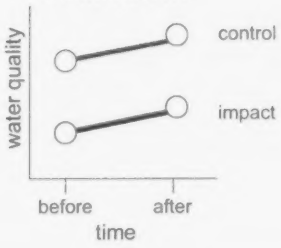
- Clear, testable hypotheses
- Contrasting treatments, incl. controls
- Replicates
- Randomized allocation of treatments
- Interspersion of treatments
- Independent response among areas
- Appropriate response variables measured

De-mystifying Adaptive Management

Steam Bank Vegetation Study: Vegetation along one stream is clearcut, other stream not clearcut

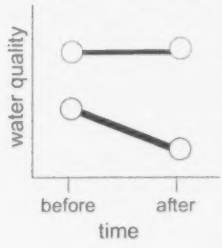


Conclusion?



- Lines parallel - no evidence of impact
- Control vs. impact reflects site differences
- Both sites experience same temporal trend

Conclusion?

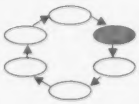


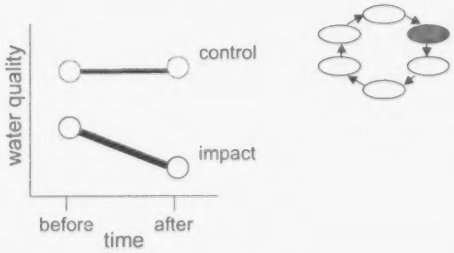
- Change over time differs between Control and Impact sites
- Impact appear to have had an effect starting when it was applied

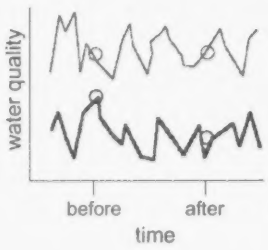
Schwarz, C.J. 1998.

De-mystifying Adaptive Management

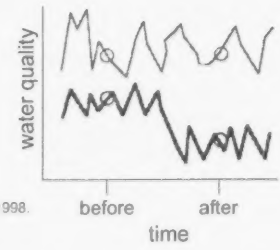
Is the conclusion correct?







Schwarz, C.J. 1998.

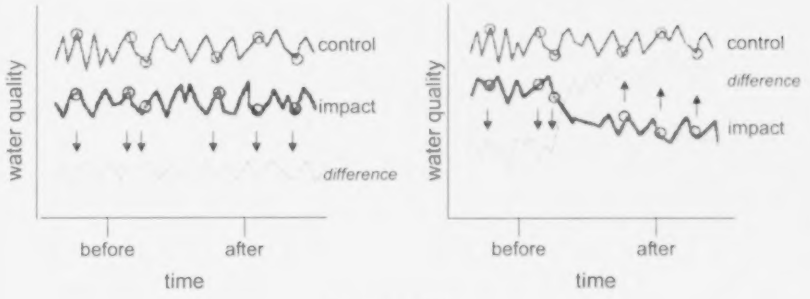


- need more then 2 samples to detect effect

De-mystifying Adaptive Management

BACI-P

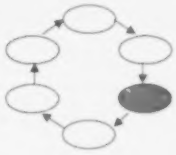
before-after control-impact, paired



Schwarz, C.J. 1998.

De-mystifying Adaptive Management

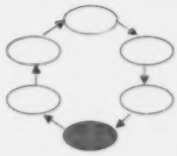
Step 3: Implement



- follow the plan
- provide interim results
- be prepared for changes!
- document/communicate deviations

De-mystifying Adaptive Management

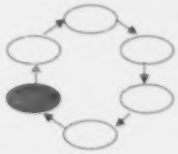
Step 4: Monitor



- follow the plan
- monitor implementation
- monitor results
- be consistent

De-mystifying Adaptive Management

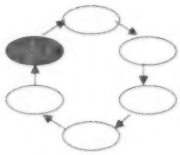
Step 5: Evaluate



- compare actual with predicted outcomes
- diagnose reasons for deviations
- assess alternative hypotheses
- document results
- communicate results

De-mystifying Adaptive Management

Step 6: Adjust



- revise hypotheses
- confirm or adjust management policy
- revise and update models
- make new predictions
- communicate actions

De-mystifying Adaptive Management

Who Should be Involved?

- managers
- ecological experts
- stakeholders
- biometrician
- policy makers
- operational staff

De-mystifying Adaptive Management

Example – Effects of forestry roads on reproductive habitat and exploitation of lake trout

Gun and Sein, 2000, Can. J. Fish. Aquat. Sci. 57(Suppl. 2):97-104.

Issue:

- large network of roads in Ontario Boreal Shield landscapes
- don't know the impact of road-related effects on aquatic ecosystems

Scenario:

- lake trout considered highly sensitive to disturbances related to forestry operations
- current guidelines require 30-90m buffer strips around lake trout lakes
- spawning sites are considered essential areas that must be protected from sedimentation
- forestry guidelines/mgmt plans usually don't adequately consider low productivity and high exploitation vulnerability typical of lake trout lakes

Uncertainty:

- the effects of spawning habitat loss and exploitation on lake trout populations

Treatments, Indicators:

2 lakes: covered spawning substrate with plastic sheeting
- trout abundance
- trout population size structure
- trout spawning activity

1 lake: forest access road within 100 m of remote lake
- angling effort
- trout population

Predictions:

- decline in juvenile abundance as a result of habitat loss
- increase in mean fish size

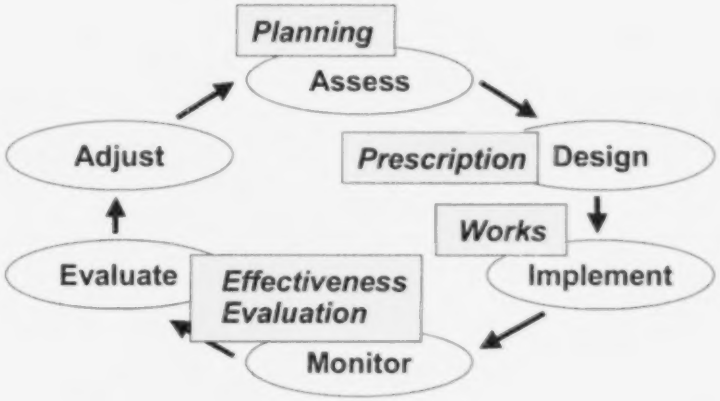
Results:

- lake trout highly adaptable to spawning habitat disturbances
  - used new spawning sites
  - continued to produce alevins from these new sites
  - no decline in abundance of juveniles
  - no increase in average fish size
- exploitation effects on lake 3 were dramatic
  - anglers used snowmobiles and ATVs for access
  - estimated max sustained yield level exceeded in 3 wks
  - estimated harvest was 3 x this level in less than 3 mos
  - 72% reduction in population size

Adjustment:

- re-visit whether fish harvest controls and improved motor vehicle access to lake trout lakes have received sufficient attention in management planning

AM and the WRP



Why adopt an AM Framework for the WRP?

- clarifies 'big picture' context for individual WRP phases
- helps focus WRP on achieving restoration objectives and ultimately WRP goals
- provides structure and rigour during planning, prescription and works phases necessary to undertake consistent and meaningful effectiveness evaluations
- highlighting explicit objective of learning will create a climate in which traditional assumptions are questioned, prescriptions are designed to reduce uncertainties, and adjustments are made that improve WRP

Implications:

- adding more rigour to the feedback part of the process
- making key uncertainties more explicit, and undertaking WRP works specifically for the purpose of reducing those uncertainties
- defining more clearly the expected outcomes of treatments at the planning stages
- rigorous and systematic monitoring of environmental variables in order to measure success of activities in achieving restoration objectives
- planning ahead for potential adjustments to policy/procedure based on what is learned